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Liquefied Gas Electrolytes for Electrochemical Energy Storage

ARPA-E Project Review Meeting

Award# DE-AR0000646

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Liquefied Gas Electrolytes for Electrochemical Energy Storage Devices

TEAM:

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Technology Overview

- Use electrolyte solvents which are gaseous, rather than liquid, at room temperature.
- Opens a new window of solvent chemistry with which to improve next-generation energy storage devices (Li-Ion Batteries, Electrochemical Capacitors)
- Potential for devices with $-60\text{ }^{\circ}\text{C}$ operation
- Potential for 20% increase in energy density

Current Status

Technical Accomplishments

- Low-temperature operation as low $-60\text{ }^{\circ}\text{C}$ for Li-Ion, $-80\text{ }^{\circ}\text{C}$ for Electrochemical Capacitor
- Highest reported electrolytic conductivities down to $-60\text{ }^{\circ}\text{C}$ demonstrated
- Retains comparable room-temperature performance
- Electrolyte chemistry compatible with common electrode, separator, and salt components

Further Technical Goals

- Explore potential increase in energy density
- Optimize chemistry for high cycle life

Next Commercial Steps

- Acquire seed funding
- Form industry partnerships
- Obtain additional IP

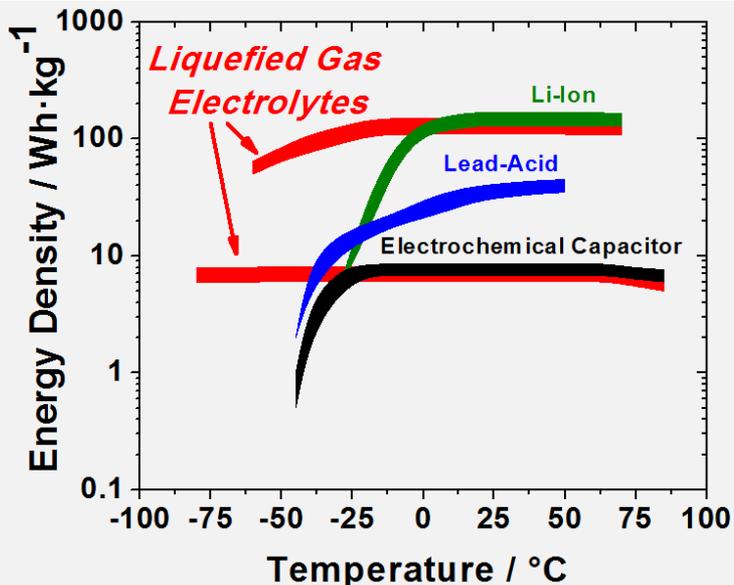
Project Statistics

Award Amount: \$300,000

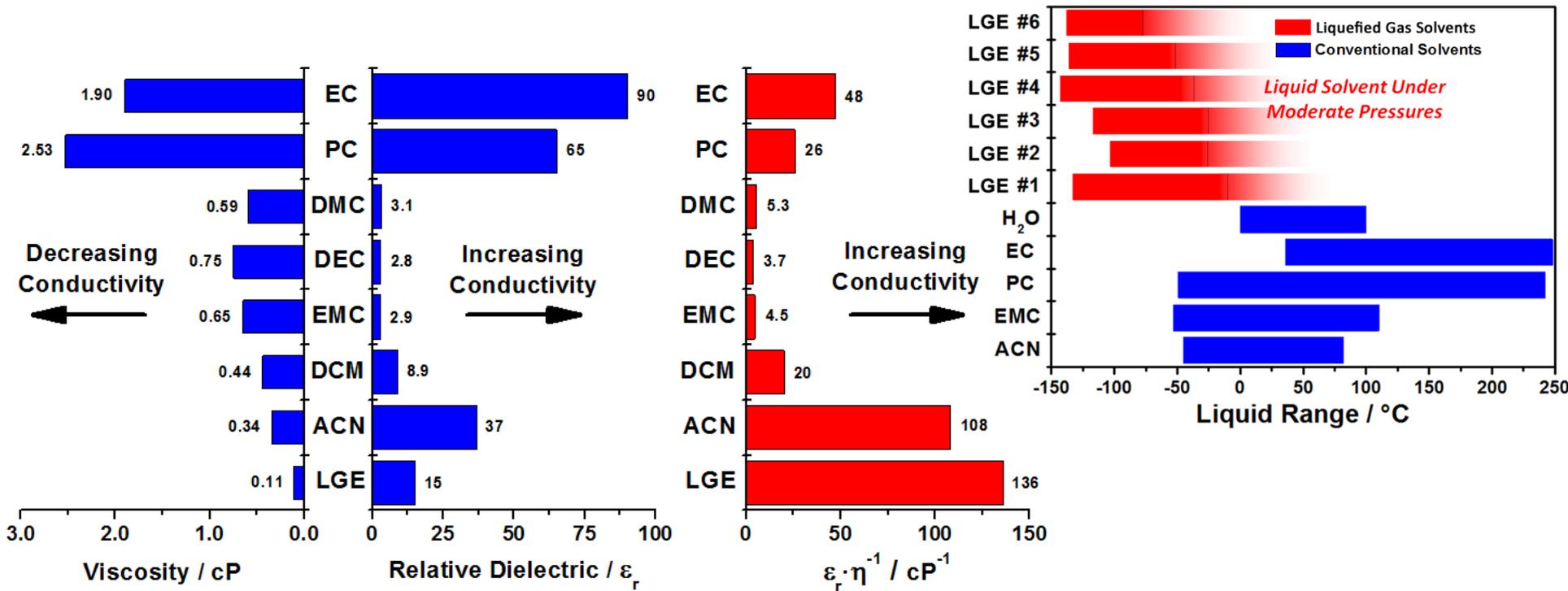
Award Timeline: 12 months

Next Stage Target: October 2016

Collaborations Sought: Battery Manufacturers



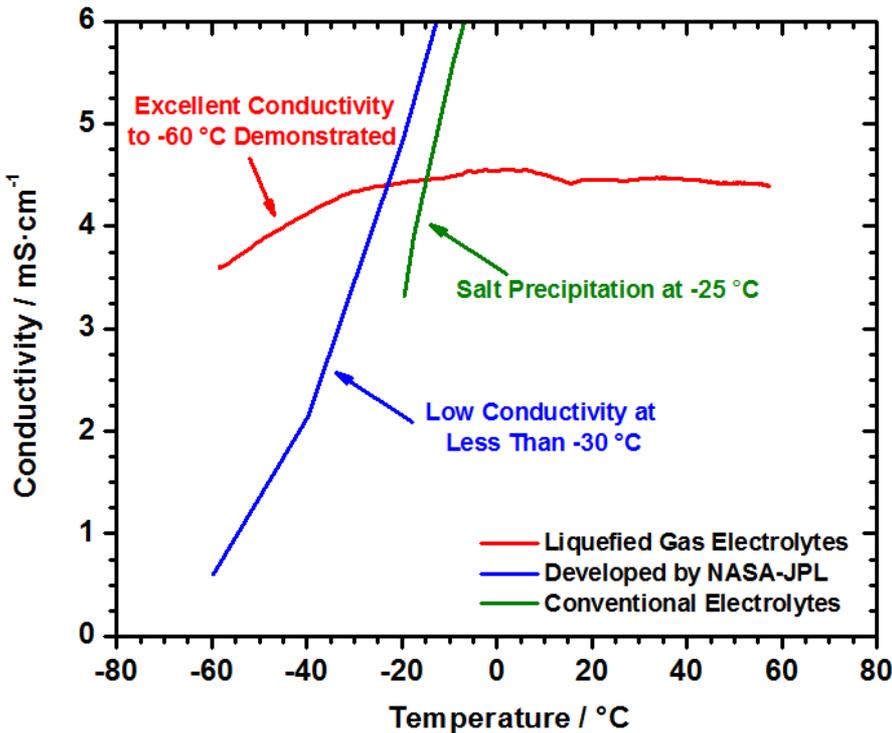
Motivation for Liquefied Gas Electrolytic



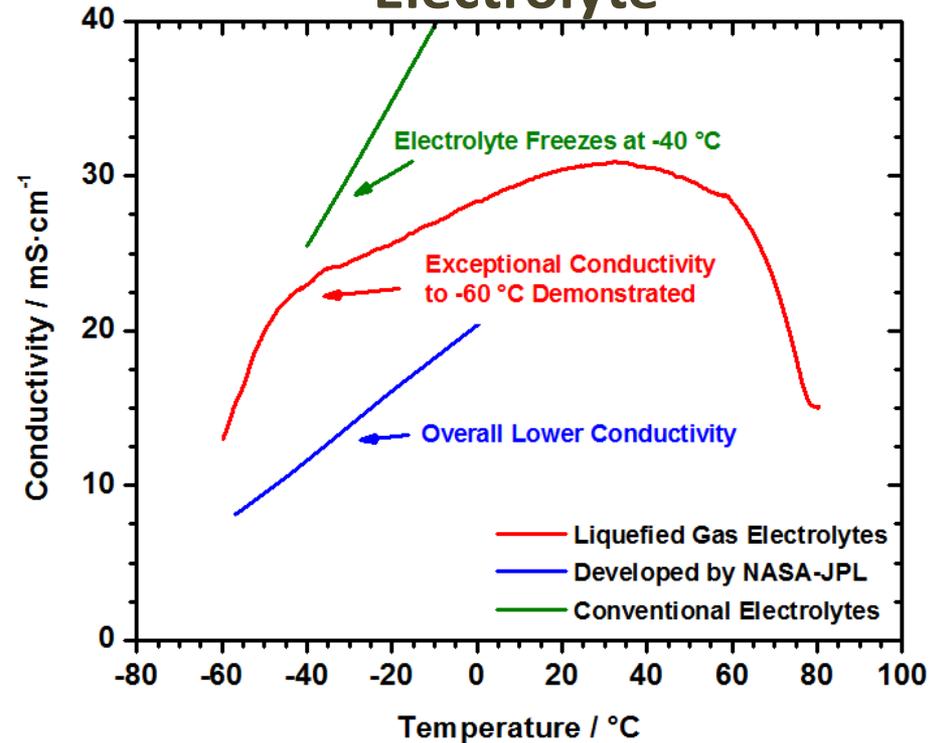
- The exceptionally low viscosity and moderate dielectric constant should give relatively high electrolytic conductivities, if salts have high enough solubility.
- The low melting EC point solvents should give excellent low temperature performance.
- At higher temperatures, the solvents have moderate vapor pressures and may be contained in a suitable mechanical cell.

Liquefied Gas Electrolytic Conductivity

Li-Ion Electrolytes



Electrochemical Capacitor Electrolyte

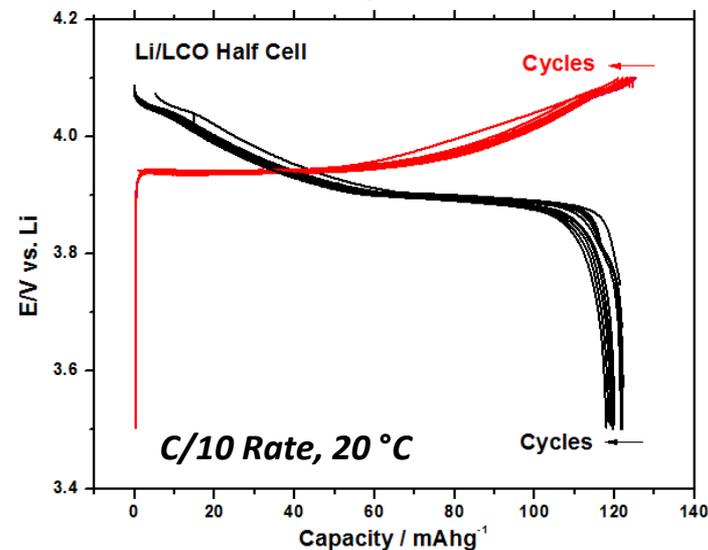
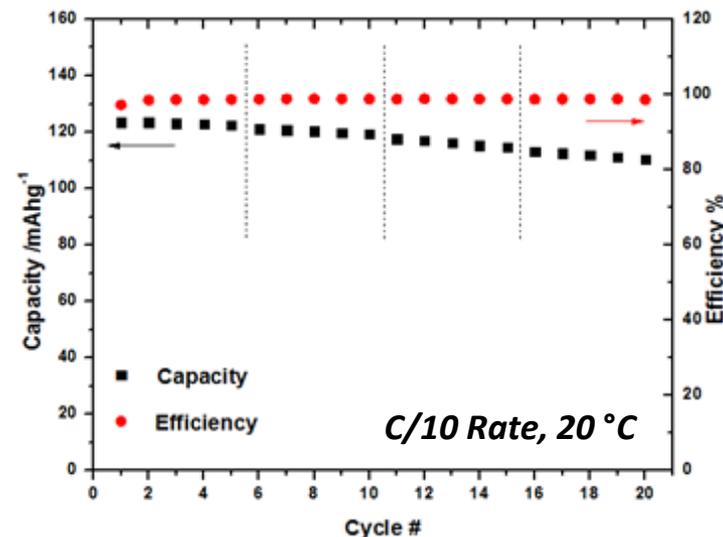
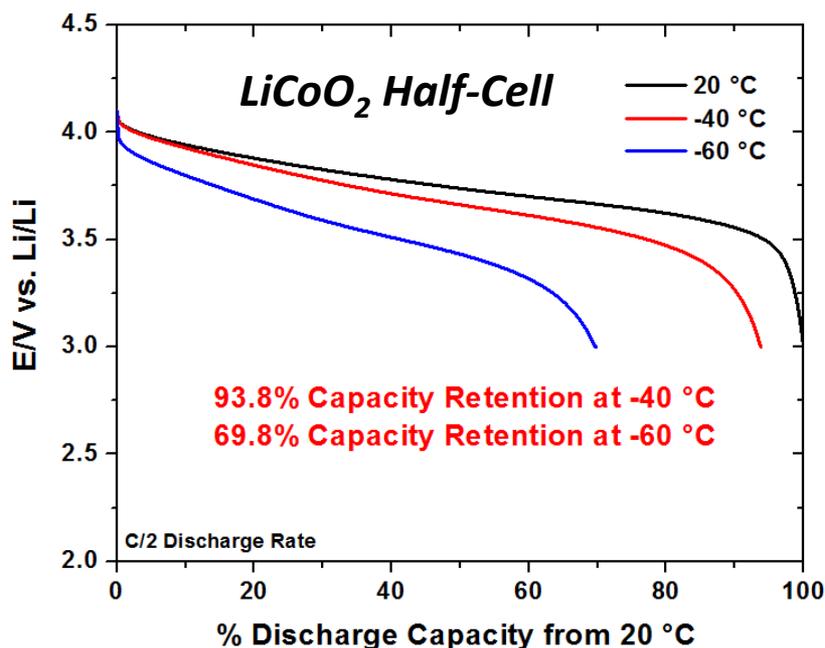


Excellent conductivity down to -60°C
Highest Conductivities of Any Published Work

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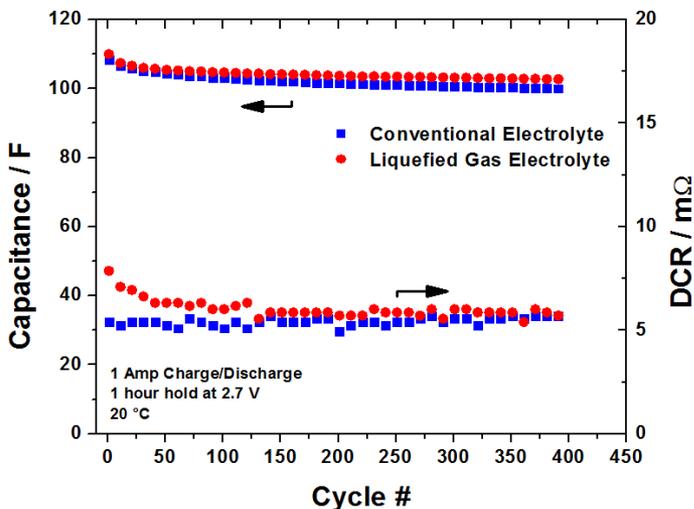
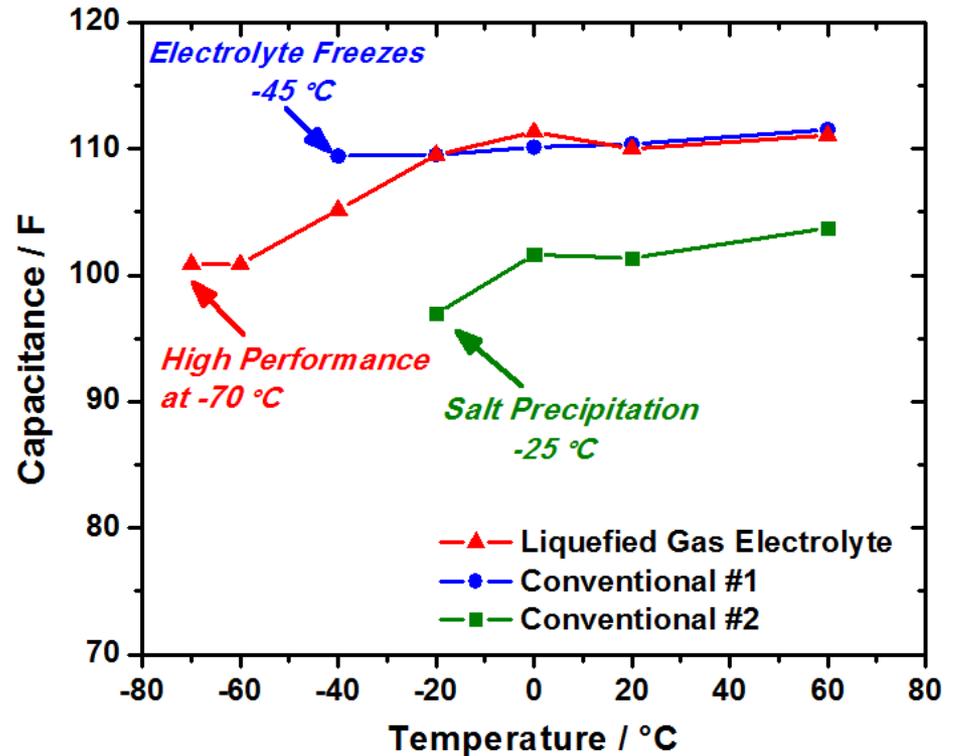
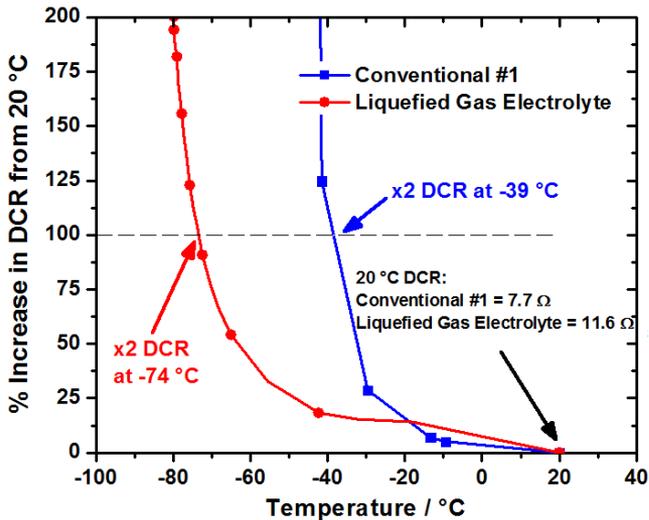


Li-Ion Performance – LiCoO₂ Half Cell



- High performance at -60 °C shown
- 20+ cycles demonstrated
- Demonstrated operation on additional electrodes:
 - Graphite
 - Li₄Ti₅O₁₂
 - LiNi_{0.5}Mn_{1.5}O₄

Electrochemical Capacitor Performance



- Exceptional performance down to -70 °C for Electrochemical Capacitors shown
- High cycle life demonstrated
- Exploring high voltage devices for increased energy

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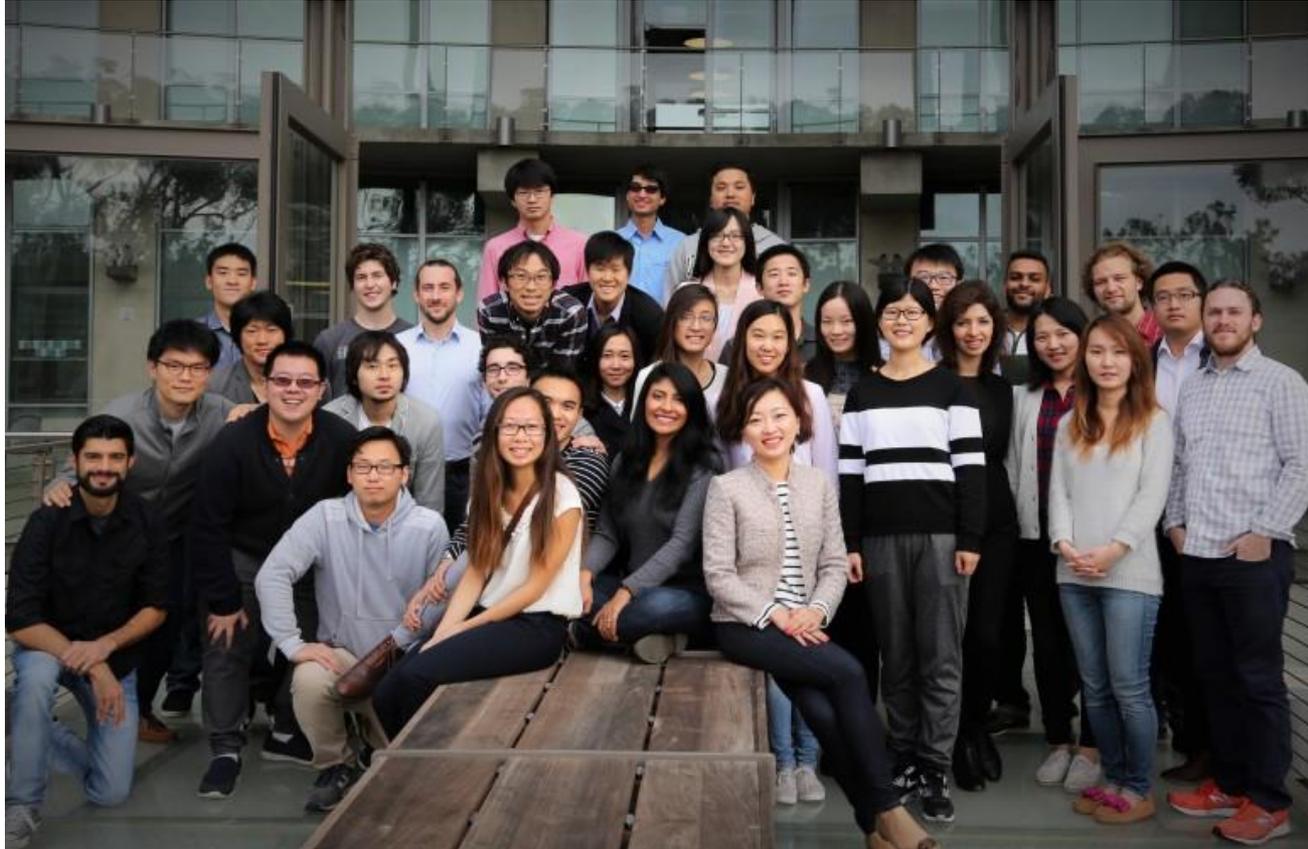
Technical

- Demonstrated the use of Liquefied Gas Electrolytes for electrochemical energy storage devices at temperatures as low as $-70\text{ }^{\circ}\text{C}$
- Identified a number of useful gaseous solvents & additives for...
 - High electrolytic conductivity
 - Increased electrochemical stability
- Goals to...
 - Increase energy density over state-of-art via alternate electrode materials
 - Improve cycle life to be comparable with state-of-art

Tech-to-Market

- Have incorporated start-up to commercialize the technology– looking for seed funding
- Would like to acquire partners in...
 - Battery/capacitor manufacturing: Pilot-line production, procuring materials, customer relationships, etc.
 - Specialty gas manufacturing: Would need liquefied gas solvents at high volumes and high purity.

Laboratory for Energy Storage and Conversion



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